THE

ASTRONOMY

OF

COMETS.

[Price 2 *s*. 6 *d*.]

THE ASTRONOMY OF COMETS.

IN TWO PARTS.

PART I. Containing a Phyfical Account of the SOLAR SYSTEM; the whole THEORY of COMETS, with the Rationale, or Phyfical Caufes of thefe Phœnomena, from the earlieft Ages to the prefent Time.

PART II. Containing the Practical Methods of Calculation. Firft, by the Properties of the Parabola without Tables; and fecondly, by Tables prefixed to the Work, with the Conftruction of the Tables, whereby the PLACE and DISTANCE of a Comet from the Earth, together with its Latitude and Longitude in the Ecliptic, may, for any Time, be known, by any one who has but a common Skill in Plane Trigonometry. The whole Procefs of Calculation exemplified in the Comet which is expected to make its Appearance in the Year 1789.

By BLYTH HANCOCK,

TEACHER OF THE MATHEMATICS.

BURY ST. EDMUND'S: PRINTED BY P. GEDGE,
FOR J. MURRAY, N° 32, FLEET-STREET, LONDON;
AND SOLD BY ALL THE BOOKSELLERS.

MDCCLXXXVI.

TO THE

Fraternity *of* United Friars;

O R,

SOCIETY *for the* PARTICIPATION *of* USEFUL KNOWLEDGE,

I N

N O R W I C H.

GENTLEMEN,

THE ſocial principle in man is of ſuch an expanſive nature, that it cannot be confined to a family, a few friends, or to a neighbourhood, but ſpreads into wider ſyſtems, and draws men into larger communities and commonwealths; in which only the ſublime powers of our nature attain the higheſt improvement and perfection of which they are capable. In ſociety, the mutual aids which men give and receive from each other,

ſhorten the labours of each; and the combined ſtrength and reaſon of individuals give ſecurity and protection to the whole body.

Your laudable deſign in encouraging and promoting the ſciences, is a ſufficient apology for my deſiring the honour of inſcribing the following ſheets to you; not doubting but that your goodneſs will pardon the liberty I have taken, as it will afford me an opportunity of teſtifying the high reſpect and eſteem with which I am,

Gentlemen,

Your moſt devoted,

moſt obedient, and

moſt humble Servant,

Norwich,
June 20, 1786.

BLYTH HANCOCK.

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OF

ECLIPSES.

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AND THE BOOKSELLERS.

PREFACE.

IN the following Treatiſe of Cometary Aſtronomy, I have endeavoured to illuſtrate the THEORY OF COMETS, ſo far as I judged any thing of that kind could be deſired or expected by the Public: for, as the time is approaching, when that part of aſtronomical knowledge, which, as yet, is but in its infancy, may receive conſiderable improvement; or, poſſibly, may be brought to as great perfection as it is capable of receiving for an age or two to come; I concluded it would be deemed an acceptable piece of ſervice to the younger ſtudents in the ſcience of Aſtronomy, to have the theory of thoſe wonderful bodies in our ſyſtem,

called

called Comets, and their motions, illuſtrated by *Practical Rules*, containing an eaſy ſolution of all the principal problems relating thereto, and applied to that very Comet on which they will ſoon have an opportunity of making their obſervations, and proving the ſame by experiments.

To this purpoſe, I have premiſed as much concerning the *Natural Hiſtory* and *Philoſophy* of Comets, as I thought could be of any uſe, having conſulted the beſt writers on that ſubject.

But, as the Theory of Comets, in the writings of thoſe learned Authors, is chiefly ſpeculative, and interwoven with great difficulties, I have ſelected thoſe parts only, which I thought would be eaſy and uſeful to ſuch readers as are but moderately verſed in trigonometry. To make ſuch ready in cometary calculations, I have added all the neceſſary tables, and ſhewn the operation in every part.

I have alſo given proper directions how to proceed in repreſenting the viſible path of a Comet on the celeſtial globe, whenever it appears; and have endeavoured altogether, as far as my abilities extended, to render the ſtudy of Cometary Aſtronomy eaſy, familiar, and entertaining.

THE direful Comets urge,
Glaring tremendous through the vaſt expanſe,
Threat'ning deſtruction, and the wrecks of worlds;
But that ſtrict bounds direct and guide their courſe,
Set, when th' ALMIGHTY, in creating hour,
From Chaos call'd the glorious Univerſe,
And fix'd the Stars, and bid the Planets move.
Where Æther's ſpace immenſe eludes our view,
And Planets in their orbs in order range,
There, free as air, the fiery Comets rove,
And direful orbs their rapid courſe extend:
Nor are their ways confus'd or intricate;
Irregular, in winding mazes loſt,
Eccentric Error, conſtant to itſelf,
To one law ſubject, one unerring rule
Of force attractive; thus, unweary'd, they
Now ſweep the utmoſt confines of the world,
Now baſking in the neighb'r'ood of the Sun,
Then ſwiftly flying his too piercing heat,
Rejoicing, they aſcend, their labours to reſume.
Long tracts of light attend their dreadful courſe,
(But truſt not to thy view a foreign light)
And ſpurious honours deck their glowing maſs;
Denſe atmoſpheres emit their furtive beams,
Frequent and thick, by heat intenſe exhal'd:
The Moon thus, with fraternal luſtre bright,
Darts borrow'd rays, and glories not her own.

INTRODUCTION.

THE enſuing Treatiſe is not intended to explain any thing new in the Theory of Comets, but rather, to render the practice of computing the returns of ſuch Comets as have been taken notice of by Aſtronomers, and to calculate their places in the Heavens, both in reſpect of longitude and latitude, where they will appear at any required or given time, either before or after their perihelion; and although ſeveral more learned, and by far more able men, have profeſſedly written thereon, yet are their works too complex and abſtruſe for the comprehenſion of learners. My ſole purpoſe is therefore to render the proceſs of calculation plain and eaſy to ſuch capacities as may not have made ſo much progreſs in mathematical ſtudies, as to comprehend what has been

written

written by more eminent authors: and this I ſhall endeavour by two methods; firſt, by the properties of the parabola, without tables; and ſecondly, by the method ſhewn by the celebrated Doctor Halley, by the help of tables, prefixed to this work; and, as an introduction to the work, ſhall give the following phyſical account of the Planetary Syſtem, and of the Theory of Comets, containing ſo much of the rationale, or phyſical cauſes of theſe phœnomena, as may be conſiſtent with my deſign.

THE

ASTRONOMY

OF

COMETS.

PART I.

ASTRONOMY is juſtly acknowledged by all men to be the moſt ancient, the moſt ſublime, the moſt intereſting, and the moſt uſeful, of all the ſciences cultivated by mankind; ſince, by the knowledge derived from this ſcience, not only the true magnitude of the Earth is diſcovered, the ſituation and extent of the countries and kingdoms upon it aſcertained, trade and commerce carried on to the remoteſt

parts of the world, and the various products of ſeveral countries diſtributed for the health, comfort, and conveniency of it's inhabitants; but our very faculties are enlarged with the grandeur of the ideas it conveys, our minds exalted above the low contracted prejudices of the vulgar, and our underſtandings clearly convinced, and affected with the conviction, of the exiſtence, wiſdom, power, goodneſs, and ſuperintendency of the Supreme Being! Alſo from this branch of knowledge we learn by what means or laws the Almighty carries on and continues the admirable harmony, order, and connection obſervable throughout the planetary ſyſtem; and are led, by very powerful arguments, to form the pleaſing deduction, that minds capable of ſuch deep reſearches not only derive their origin from that all-wiſe and adorable Being, but are alſo incited to aſpire after a more perfect knowledge of his nature, and a ſtricter conformity to his will.

By Aſtronomy we are enabled to diſcover that the Earth is at ſo great a diſtance from the

the Sun, that, if ſeen from thence, it would appear no bigger than a point, although it's circumference is known to be 25,020 miles: yet that diſtance is ſo ſmall, compared with the diſtance of the fixed Stars, that, if the orbit in which the Earth moves round the Sun were ſolid, and ſeen from the neareſt fixed Star, it would likewiſe appear no bigger than a point, although it is at leaſt 162 millions of miles in diameter: for the Earth, in going round the Sun, is 162 millions of miles nearer to ſome of the Stars at one time of the year than at another; and yet their apparent magnitudes, ſituations, and diſtances from one another, ſtill remain the ſame, and a teleſcope which magnifies 200 times, does not ſenſibly magnify them; which proves them to be at leaſt four hundred thouſand times farther from us than we are from the Sun.

This inconceivable diſtance of the fixed Stars does wholly diveſt them of all parallaxes; for I know not of any one fixed Star in the Heavens, the Great Dog Star only

 excepted,

excepted, that has any parallax, and he a parallax of only two ſeconds, which places him at the amazing diſtance of two billions, or two millions of millions of miles from the centre of the ſyſtem; ſo that if a cannon ball was projected from the ſurface of our Earth, and travelling with the ſame velocity with which it leaves the mouth of the cannon, it would not reach the neareſt fixed Star in five hundred thouſand years: I ſay the neareſt fixed Star; for we are not to imagine or ſuppoſe that all the Stars are placed in one concave ſurface, ſo as to be equally diſtant from us, but that they are ſcattered at immenſe diſtances from one another through infinite and unlimited ſpace; ſo that there may be as great a diſtance between any two neighbouring Stars, as between our Sun and thoſe which are neareſt to him: therefore an obſerver, who is neareſt any fixed Star, will look upon it alone as a real Sun, and conſider the reſt as ſo many ſhining points, placed at equal diſtances from him in the firmament. By the help of teleſcopes we diſcover thouſands of Stars, which are

invìſible

invisible to the naked eye; and the better our glasses are, still the more become visible: so that we can set no limits, either to their number or their distances; nor can we reasonably suppose that the different apparent magnitudes of the Stars is in anywise owing to one Star being less or bigger than another, but wholly to their being at a less or greater distance from us; as it is most proveable, that they are all nearly of the same size one with another, and all nearly of the same magnitude with the Sun. The Sun appears very bright and large, in comparison of the fixed Stars, because we keep constantly near the Sun, in comparison of our immense distance from the Stars: for a spectator, placed as near to any Star as we are to the Sun, would see that Star a body as large and bright as the Sun appears to us; and a spectator, as far distant from the Sun as we are from the Stars, would see the Sun as small as we see a Star, divested of all it's circumvolving Planets, and would reckon it one of the Stars in numbering them.

The Stars being at ſuch immenſe diſtances from the Sun, cannot poſſibly receive from him ſo ſtrong a light as they ſeem to have, nor any brightneſs ſufficient to make them viſible to us; for the Sun's rays muſt be ſo ſcattered and diſſipated before they reach ſuch remote objects, that they can never be tranſmitted back to our eyes, ſo as to render theſe objects viſible by reflection. The Stars therefore ſhine with their own native and unborrowed luſtre, as the Sun does; and ſince each particular Star, as well as the Sun, is confined to a particular portion of ſpace, it is plain that the Stars are of the ſame nature with the Sun. It is no ways probable, nor is it reaſonable for any man to think, that the Almighty, who always acts with infinite wiſdom, and does nothing in vain, ſhould create ſo many glorious Suns, fit for ſo many important purpoſes, and place them at ſuch diſtances from one another, without proper objects near enough to be benefited by their influences: whoever therefore ſhould be weak enough to imagine they were created only to give a faint glimmering light to the

inhabitants of this globe, muſt have a very ſuperficial knowledge of Aſtronomy, and a mean and contracted opinion of the Divine wiſdom; ſince, by an infinitely leſs exertion of creating power, the Deity could have given our Earth much more light by one ſingle additional Moon. Inſtead then of one Sun and one World only in the univerſe, as the unſkilful in Aſtronomy imagine, that ſcience diſcovers to us ſuch an inconceivable number of Suns, Syſtems, and Worlds, diſperſed through boundleſs ſpace, that if our Sun, with all the Planets, Moons, and Comets belonging to it, were annihilated, they would be no more miſſed out of the creation, than a grain of ſand from the ſea ſhore; the ſpace they poſſeſs being comparatively ſo ſmall that it would ſcarce be a ſenſible blank in the univerſe; although Saturn, the outermoſt of our Planets, revolves about the Sun in an orbit of 4,884 millions of miles in circumference, and ſome of our comets make excurſions upwards of 10,000 millions of miles beyond Saturn's orbit; and yet, at that amazing diſtance, they are incomparably nearer

nearer to the Sun than to any of the Stars, as is evident from their keeping clear of the attractive power of all the Stars, and returning periodically by virtue of the Sun's attraction. From what we know of our Syſtem, it may be reaſonably concluded, that all the reſt are with equal wiſdom contrived, ſituated, and provided with accommodations for rational inhabitants.

To him who attentively conſiders, it will appear highly probable, that the Planets, together with their attendants, called Satellites or Moons, are much of the ſame nature with our Earth, and deſtined for the like purpoſes; for they are ſolid opaque globes, capable of ſupporting animals and vegetables. Some of them are bigger, ſome leſs, and ſome much about the ſize of our Earth. They all circulate round the Sun, as the Earth does, in a ſhorter or longer time, according to their reſpective diſtances from him; and have, where it would not be inconvenient, regular returns of ſummer and winter, ſpring and autumn. They have

warmer

warmer and colder climates, as the various productions of our Earth require; and in such as afford a possibility of discovering it, we observe a regular motion round their axis, like that of our Earth, causing an alternate return of day and night, which is necessary for labour, rest, and vegetation; and that all parts of their surfaces may be exposed to the rays of the Sun. Such of the Planets as are farthest from the Sun, and therefore enjoy least of his light, have that deficiency made up by several Moons, which constantly accompany and revolve round about them, as our Moon revolves about the Earth. The remotest Planet has, over and above, a broad ring encompassing it, which, like a lucid zone in the Heavens, reflects the Sun's light very copiously on that Planet; so that if the remoter Planets have the Sun's light fainter by day than we, they have an addition made to it morning and evening by one or more of their Moons, and a greater quantity of light in the night time.

By reaſon of the vicinity of the Moon to our Earth, we diſcover a nearer reſemblance to our Earth; for by the aſſiſtance of teleſcopes we obſerve the Moon's ſurface to be full of high mountains, large valleys, and deep cavities. Theſe ſimilarities leave us no room to doubt, but that all the Planets and Moons in the ſyſtem are deſigned as commodious habitations for creatures endowed with capacities of knowing and adoring their beneficent Creator.

Since then the fixed Stars are prodigious ſpheres of fire, like our Sun, and placed at ſuch immenſe and inconceivable diſtance from us and from one another, how can we reaſonably conclude but that they are made for the ſame purpoſes that the Sun is; each to beſtow light, heat, and vegetation, on a certain number of inhabited Planets, kept by gravitation within the ſphere of its activity.

But what makes the moſt wonderful and moſt ſurpriſing part of the Solar Syſtem, are

thoſe

thoſe bodies called Comets, whoſe number is very great; near forty have already been obſerved, with ſo much accuracy as to leave little room to doubt, that they are all different from each other. And a much greater number ſtill are recorded in hiſtory, for one author has reckoned no leſs than 415 in number, to the year 1665 incluſive; but though the number be certainly very great, it may require many ages to determine what the number really is.

Diodorus Siculus tells us, that the Chaldeans, by a long courſe of obſervations, were able to predict the appearance of Comets: and Seneca ſays, that Apollonius the Myndian, who was very ſkilful in natural ſciences, affirmed, that Comets were by the Chaldeans reckoned among the Planets, and had their periods or courſes like them. Seneca further tells us, that Apollonius uſed to ſay, that a Comet was a Star or Celeſtial body like the Sun or Moon; but that he did not know its courſe, becauſe it ranges through higher parts of the world, and then at laſt appears

appears, when it comes to the bottom of its course. Of which opinion Seneca himſelf profeſſes himſelf to be, in theſe words: "I don't think a Comet to be a ſudden fire, but one of the eternal works of Nature;" he alſo gives the ſole and only method by which this queſtion may be ſolved, ſaying, "that there ought to be a collection of former riſes or appearances of Comets; becauſe by reaſon of their ſeldom appearing, their courſes cannot yet be underſtood, neither can it be diſcovered whether they return or no; and that they appear or are produced in order at their ſettled time. A *time*, ſays he, will come when thoſe things, which are now hid, will at laſt be brought to light, by length of time and the diligence of poſterity. One age is not ſufficient to make ſuch great diſcoveries. A time will come when thoſe that come after us will wonder that we were ignorant of things ſo plain." And farther on he ſays, "Somebody will demonſtrate, which way Comets wander, why they go ſo far from the reſt of the celeſtial bodies, how big, and what ſort of bodies they are." All theſe predictions have

been

been accurately fulfilled and compleated in Sir Iſaac Newton.

Notwithſtanding Seneca has ſo clearly diſcourſed on the nature of Comets in that dark age, yet few of the ſucceeding aſtronomers were of his opinion, for they generally eſteemed them as meteors kindled in the air, and deſigned as preſages, or unlucky omens of ſome diſaſtrous cataſtrophe, that was ſhortly to befall the people or nations to whom they appeared. Nor did Seneca himſelf think fit to ſet down thoſe phœnomena of the cometary motions, by which he was enabled to maintain his opinion, nor the times of thoſe appearances which might have been of uſe to poſterity, in order to the determining theſe things. Afterwards, the whole ſchool of Peripateticks, to keep up their doctrine concerning the Heavens, which they ſuppoſed not capable of being generated or corrupted, did not look upon the Comets as eternal or permanent bodies of the world, but as bodies newly produced, and in a ſhort time to periſh again, and affirmed them to

be

be ſublunary, and made of exhalations in the terreſtrial regions; which was the more believed after ſolid orbs were introduced, becauſe Comets could not paſs through them. But at laſt, Tycho Brahe and Kepler, finding by obſervation, that Comets had no diurnal parallax, reſtored them to places above the Moon. All which has been fully and clearly demonſtrated by Sir Iſaac Newton, who ſays, that Comets are higher than the Moon, and are moved in the region of the primary Planets; and that they move in conic ſections, having their focus in the center of the Sun; and by rays drawn to the Sun, deſcribe equal areas in equal times, and in general, areas proportional to the times. Thus following the ſteps of ſo great a man, we may venture to affirm, that Comets are opaque, ſpherical, and ſolid bodies like the Planets, and like them perform their revolutions about the Sun in elliptical orbits, having the Sun in one of their foci. The particulars in which Comets differ from the Planets are, that they move in various directions, ſome the ſame way with the Planets, others the contrary;

contrary; neither are their motions confined within the zodiac, their orbits admitting of any inclination to the ecliptic whatever: and the eccentricity of their orbits is ſo very great, that ſome of the Comets perform the greateſt part of their motion almoſt in right lines, tending, in their approach to the Sun, almoſt directly towards it, after which they paſs by it, and when they leave it, move off again nearly in a right line, till they are out of ſight, as if they were haſtening back to the fixed Stars, and return not till after a period of many years.

Comets were looked upon by the ancients in general, as nothing more than ſublunary vapours, or fiery meteors, as has before been remarked, and conſequently little notice was taken of them, till the year 1577, when Tycho Brahe, ſeriouſly purſuing the ſtudy of the Stars, and being provided with large inſtruments fit for making celeſtial obſervations, with far greater care and certainty than the ancients could ever hope for, there appeared a very remarkable Comet; to the obſervation

ſervation of which Tycho vigorouſly applied himſelf; and found by many juſt and faithful trials, that it had not a diurnal parallax that was at all perceptible, and conſequently was not only no aerial vapour, but alſo much higher than the Moon; nay might be placed amongſt the Planets, for any thing that appeared to the contrary; the cavilling oppoſition made by ſome of the ſchool-men in the mean time, being to no purpoſe. Next to Tycho came the ſagacious Kepler, who, with the advantage of Tycho's labours, and by his own obſervation, found out the true phyſical ſyſtem of the world, and greatly improved the ſcience of Aſtronomy. This great Aſtronomer had an opportunity of obſerving two Comets, one of which was a very remarkable one, and from the obſervations of theſe (which afforded ſufficient indications of an annual parallax) he concluded, that the Comets moved freely through the planetary orbs, with a motion not much different from a rectilinear one; but of what kind he could not then preciſely determine. Next Hevelius (a noble

emulator of Tycho Brahe) following Kepler's ſteps, embraced the ſame hypotheſis of the rectilinear motion of Comets, himſelf accurately obſerving many of them, yet he complained that his calculations did not perfectly agree to the matter of fact in the Heavens; and was aware that the path of a Comet was bent into a curve line towards the Sun: at length came that prodigious Comet of the year 1680, which deſcending as it were from an infinite diſtance, perpendicularly towards the Sun, aroſe from him again with as great a velocity. This Comet, which was ſeen for four months ſucceſſively, by the very remarkable and peculiar curvity of its orbit, above all others, gave the fitteſt occaſion for inveſtigating the theory of its motion. And the royal obſervatories at Greenwich and Paris having been for ſome time founded, and committed to the care of moſt excellent aſtronomers, the apparent motion of this Comet was moſt accurately (perhaps as far as human ſkill could extend) obſerved by Mr. Flamſteed and Mr. Caſſini. Not long after, the illuſtrious Newton, wri-

ting his Mathematical Principles of Natural Philoſophy, demonſtrated, not only that what Kepler had found did neceſſarily obtain in the planetary ſyſtem; but alſo, that all the phænomena of Comets would naturally follow from the ſame principles: which he abundantly illuſtrated by the example of the aforeſaid Comet of the year 1680, ſhewing at the ſame time a method of delineating the orbits of Comets geometrically.

That Comets are not aerial vapours, or even formed by exhalations from the Sun and Planets, Sir Iſaac Newton has clearly ſhewed; by proving that the Comet of 1680, in its paſſage through the ſolar regions, would have been diſſipated, had it conſiſted of ſuch; for the heat of the Sun, it is allowed, is as the denſity of his rays, *i. e.* reciprocally, as the ſquares of the diſtances of places from the Sun; wherefore, ſince the diſtance of that Comet in its perihelion, December the 8th, was obſerved to be to the diſtance of the Earth from the Sun, nearly as 6 to 1000, the Sun's heat in the

Comet,

Comet, at that time, was to his heat with us at Midſummer, as 1,000,000 to 36, or 28,000 to 1. It is found by experiment, that the heat of boiling water is little more than three times the heat of our dry Earth, when expoſed to the Midſummer Sun; and aſſuming the heat of red hot iron to be about three or four times as great as that of boiling water, he thence concludes, that the heat of the dried earth, or body of the Comet in its perihelion, muſt be near 2000 times as great as that of red hot iron. Such an immenſe heat once acquired in its perihelion, the Comet muſt be a long time in cooling again. Sir Iſaac Newton alſo computes, that a globe of red hot iron, of the dimenſions of our Earth, would ſcarce be cool in 50,000 years. If then the Comet be ſuppoſed to cool 100 times as faſt as red hot iron; yet ſince its heat was 2000 times greater, ſuppoſing it of the bigneſs of the Earth, it would not cool in a million of years.

There is one remarkable phænomenon, which ſometimes, though very ſeldom, ac-

companies the paſſage of Comets in their orbits, and that is, what may be called Cometary Eclipſes; for when a Comet comes in the ſyzigial line of the Sun and the Earth, it muſt very much abate the ſolar light, though its viſual diameter may not equal it: but if it ſhould equal, or exceed it (and ſuch have made their appearance) if their courſe be not exceedingly rapid, the Sun will be darkened through a much greater extent of Earth, for a much longer duration, and attended with a more remarkable obſcurity, than any circumſtances of a ſolar eclipſe ever can be; ſuch poſſibly might be the Egyptian darkneſs in the Jewiſh hiſtory, that of Jupiter and Alcmena in the Grecian, and of Auguſtus in the Roman; beſides others, unrecorded in the annals of hiſtory. With reſpect to the tail of a Comet, Sir Iſaac infers, that it is nothing elſe but a very fine vapour, which the head or nucleus of the Comet emits by its heat; and that the magnitude of the tail depends principally upon the degree of heat it receives from the Sun, as is evident from obſervation: for, till the Comet comes within a

certain diſtance of the Sun, it is not ſeen with any train at all; as it approaches nearer, and the heat increaſes, the tail begins to ariſe, and grows longer about the perihelion, and a little diſtance after it is largeſt of all; then, as the heat of the Sun decreaſes, the length of the tail decreaſes alſo, till at laſt it no more appears: therefore the tail of a Comet is cauſed by heat, and is always proportional to it. Thus alſo the Comets which are neareſt the Sun have, generally ſpeaking, the longeſt tails; and thoſe which are more remote, the ſhorteſt. But it may ſeem wonderful to ſome, how thoſe prodigious tails are, or can be ſupplied from the atmoſphere of a Comet: Sir Iſaac has removed that wonder, by a computation which he had made on the expanſive power, or force of an elaſtic fluid, ſuch as our air, which is more denſe near the ſurface of the Earth, where it is preſſed upon by the whole weight of the air above, than it is at a diſtance from the Earth, where it has a leſs weight to compreſs it; the denſity of the air being always proportioned to the force which compreſſes

it, and consequently the air will expand itself, and become more rare in proportion as it becomes less compressed. From hence, Sir Isaac computes to what degree of rarity the air must be expanded, according to this rule, at an height equal to that of the semidiameter of the Earth (which is about 4000 miles); and he finds that a globe of such air as we breathe here on the surface of the Earth, which is only one inch in diameter, if it were expanded to a degree of rarity, which the air must have at the height of one semidiameter of the Earth, would fill all the planetary regions, even to the very sphere of Saturn, and much farther. Wherefore, seeing the air at a greater height is still immensely more rarefied, and the surface of the atmospheres of Comets' tails is usually about ten times the distance from the center of the Comet, as the surface of the Comet itself, and the tails rise yet to vastly greater heights, therefore they must be exceedingly rare; and though, on account of the much denser atmospheres of Comets, and the greater gravitation of their bodies towards the Sun, as

well as of the particles of their air and vapours mutually one towards another, it may happen that the air in the celeſtial ſpaces, and in the tails of the Comets, is not ſo vaſtly rarefied, yet, from ſuch a computation, it is plain that a very ſmall quantity of air and vapour is abundantly ſufficient to produce all the appearances of the tails of Comets; and that the tails of Comets are very rare indeed, is evidently proved by the ſhining of Stars through them, without the leaſt diminution of their ſplendour. The light reflected from the tail of a Comet is not near what we are uſually prone to think it to be: Sir Iſaac ſays, it is not greater than that of our air, determined by the Sun-beams let into a darkened room through a hole in the window-ſhutter, an inch or two in diameter. This alſo fully appears from viewing the tail of a Comet with a teleſcope, which always to the obſerver appears very faint and languid, even in the denſer parts of it, and the extreme parts of the tail make no appearance at all through a teleſcope.

As to the cauſe of the aſcent of the tail, Kepler aſcribes it to the rarefaction of the Comet's atmoſphere by the heat of the Sun, and the impulſive force of the Sun-beams carrying along with them the matter of the Comet's tail; which alſo accounts, at the ſame time, for the direction or poſition of the Comet's tail, which is always towards thoſe parts oppoſite to the Sun. Since the phænomena of a Comet's tail depend upon the heat of the Sun, as has been obſerved, and ſince the nucleus or body of a Comet is heated to that prodigious degree as before-mentioned, it is but reaſonable to ſuppoſe, that the action of the Sun's light upon thoſe ignited particles of the Comet, and its heated atmoſphere, ſhould carry them away in their own directions, and ſo cauſe that appearance of a train of light, or the blazing tail of a Comet. Now, if we rightly conſider the nature of things, the particles of light agitate and put all the parts of bodies in motion, particularly the parts of fluid bodies; and thoſe parts of bodies, whether ſolid or fluid, that are ignited, or real fire, evidently

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loſe their ignited particles, and by degrees become extinct, only by the action of the Sun's rays. Thus a fire, expoſed to the Sun-beams, appears immediately to be diveſted of its ignited parts; the flame gradually leſſens, the glowing coals by degrees become wholly extinct, and the fire goes out: alſo the flame of a ſpirit-lamp loſes all its light in the Sun-beams, and the denſer flame of a candle burns languid in the Sun; and many phœnomena of a ſimilar nature have been frequently obſerved by the curious. Nay, ſome philoſophers, who have had the advantage of very large burning-glaſſes, four or five or more feet in diameter, have told us, that they have rendered this impulſive force of the rays of light upon bodies ſenſible to the eye; for by ſeveral experiments, which they have favoured us with an account of their having tried on light bodies ſuſpended by a fine thread, and then throwing the denſe rays of light near the focus of the glaſs upon them, it has manifeſtly put them in motion, and they have been obſerved to vibrate backward and forward like the pen-

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dulum of a clock: whence there can be no diſpute but that the parts of bodies may be propelled and carried forward by the particles of light in their own direction; and though ſuch effects of the Sun's rays are very ſmall, and almoſt inſenſible, here with us, where the parts of matter are very groſs, and confined in a denſe atmoſphere, yet the caſe is undoubtedly far otherwiſe in thoſe free ſpaces through which the Comets move, where ſcarcely any reſiſting medium can be ſuppoſed, and where the matter of a Comet's tail is very fine, and liable to be put in motion with the leaſt degree of force, much more by the prodigious impetus of a particle of light moving with a velocity not to be expreſſed or conceived. Agreeably to this notion of the cauſe of the aſcent of a Comet's tail, we find the general form of the tail is that of a dilating vapour, growing wider towards the extreme parts, eſpecially when they attain to their full degree of heat, and greateſt magnitude. That the tail does or ſhould lie in a right line direction from the Sun, we have no reaſon to ſuppoſe, unleſs

lefs it were to move in a real vacuum, or empty fpace; for though the medium through which the Comet moves may be exceeding rare and fine, yet fome degree of refiftance will arife to fo large a moving body as the tail of a Comet, and the more rare the tail is, the greater refiftance it will meet with from the medium; therefore the tail muft be in fome degree incurvated, or left a little behind the Comet in its motion, fomewhat like the flame of a candle when it is moved gently forward through the medium of air; and hence it is that we fee all the tails of the Comets deviating from a right line paffing through the Sun and the Comet, but moftly fo towards the extreme part.

Sir Ifaac has alfo, in the ftrongeft light imaginable, reprefented the extenfive providence of the Supreme Creator of the Univerfe, who, befides the furnifhing our Earth, and, without doubt, the reft of the Planets, fo abundantly with every neceffary for the fupport and continuance of the numerous

races of plants and animals they are ſtocked with, has over and above provided a numerous train of Comets, far exceeding the number of Planets, to rectify continually and reſtore their gradual decay. For ſince the Comets are ſubject to ſuch very unequal degrees of heat, being ſometimes ſcorched with the moſt intenſe degree of it, at other times ſcarce receiving any ſenſible influence from the Sun, it can ſcarcely be ſuppoſed that they are deſigned for any ſuch conſtant uſe as the Planets. As to the tails which they emit, they muſt, like all other kinds of vapour, dilate themſelves as they aſcend, and conſequently are gradually ſcattered and diſperſed through all the planetary regions, and therefore cannot but mix with the atmoſpheres of the Planets; for it is well known the Planets have one and all an attractive power, by which they cauſe all bodies to gravitate towards them; and therefore, in proceſs of time, theſe vapours will be drawn into one or other of the Planets, whichever happens to be neareſt, and acts the ſtrongeſt upon them; and by entering

the atmoſpheres of the Earth, or other Planets, may very naturally be ſuppoſed to contribute to the renovation of the face of things, in particular to ſupply the diminution cauſed in the humid parts by vegetation and putrefaction; ſince vegetables are nouriſhed by moiſture, and are alſo by putrefaction turned in a conſiderable part into dry earth: for it is well known that earthy ſubſtances will always ſubſide in fermenting liquors; whence, by the ſame means, it is very reaſonable to conclude that the dry parts of the Planets are continually increaſing, and the fluid parts diminiſhing, and in a ſufficient length of time may be exhauſted, if they are not ſupplied by ſome other means.

Sir Iſaac is alſo of opinion, that the moſt ſubtle and active parts of our air, upon which the life of animals and vegetables do chiefly depend, is derived to us and ſupplied by the Comets; ſo far are they from portending any hurt or miſchief to us, which the natural fears of ſome men are too apt to ſurmiſe,

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from the appearance of any thing uncommon and aſtoniſhing.

Sir Iſaac alſo ſuppoſes, that the reſiſtance which Comets meet with from the atmoſphere of the Sun and of the medium of the planetary regions, muſt occaſion a retardation of their motion in ſome ſmall degree, which may be alſo further promoted by the attraction of the larger Planets; the conſequence of which will be, that the central force will bring them nearer and nearer the Sun in each revolution, till at length they fall into him, and ſupply fuel to that immenſe body of fire. Sir Iſaac has carried this ſuppoſition ſo far as to ſay, that fixed Stars (or Suns of other ſyſtems) that had been gradually waſted by light and vapours emitted from them for a long time, may be re-kindled by the Comets of their ſyſtems falling upon them, and from this freſh ſupply of new fuel, thoſe old Stars acquiring new ſplendour, make thoſe new Stars which we often obſerve ſuddenly appear in the Heavens, and ſhine with wonderful bright-

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neſs at firſt, and afterwards vaniſh by little and little, of which he enumerates many inſtances.

Nay, further ſtill, Sir Iſaac thinks it not unreaſonable to imagine, that the exhalations that ariſe from the Sun, the fixed Stars, and the tails of Comets, may at laſt meet with and fall into the atmoſpheres of the Planets, by their gravity, and there be condenſed and turned into water and humid ſpirits; and from thence, by a ſlow heat, paſs gradually into the form of ſalts, ſulphurs, and tinctures, and mud, and clay, and ſands, and ſtones, and coral, and other terreſtrial ſubſtances.

The near approach of ſome Comets to the Earth's orbit at particular times, may afford very good opportunities of determining the parallax of the Sun, as their parallaxes are very much larger than that of the Sun, in their perigeums. Dr. Halley ſays, that he found by calculation the Comet of 1680, on November 11 d. 1 h. 6 m. was not above

the ſemidiameter of the Sun to the northward of the Earth's path; and had the Earth been there then, he thinks the parallax of the Comet would have equalled that of the Moon.

Some other uſes may be made of the doctrine of Comets; as, that they entirely deſtroy the arbitrary hypotheſis of Carteſian Vortices, by their regular and free motions in all directions, through every part of the Heavens; as alſo of the ſolid orbs in which the Planets were ſuppoſed to move by the vain imaginatian of ignorant ſchoolmen; and laſtly, the argument againſt the eternity of the univerſe, drawn from the gradual decay of the Sun, ſtill ſubſiſts, and receives new force from this theory of the Comets.

How far the fate of the planetary ſyſtem may be affected by Comets, or particularly what may happen in proceſs of time to our Earth, I cannot take upon me to ſay; ſince, among ſuch a number revolving Comets, with ſuch prodigious tails attending them

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through the planetary regions, and moving in all directions among the planetary orbs, there muſt be ſomething more than common chance ſuppoſed to guard the Planets from ſhocks againſt the bodies of Comets, and immerſions into their tails. There could be no ſecurity againſt ſuch alarming accidents, were it not for the conſideration, that all the motions of the univerſe were at firſt deſigned and produced by a Being, of infinite ſkill to foreſee the moſt diſtant conſequences. Our Earth has hitherto been out of the way when theſe Comets have paſſed by; but it requires a perfect knowledge of the motion of Comets, to be able to judge if they will always viſit us in ſo inoffenſive a manner.

It is not indeed poſſible to ſay how far the Earth may be affected by being involved in the tail of a Comet, eſpecially in the denſer part, near the atmoſphere; and it is to be preſumed, that we ſhould all be willingly excuſed from this piece of knowledge by experiment. Doctor Gregory has given us his opinion, that if the tail of a Comet

ſhould touch the atmoſphere of our Earth, (or if a part of this matter, ſcattered and diffuſed about the Heavens, ſhould fall into it) the exhalations of it mixed with our atmoſphere (one fluid with another) may cauſe very ſenſible changes in our air, eſpecially in the animals and vegetables; for vapours brought from ſtrange and diſtant regions, and excited by a very intenſe heat, may be prejudicial to the inhabitants or products of the Earth: wherefore, ſays the Doctor, thoſe things which have been obſerved by all nations, and in all ages, to follow the apparition of Comets, may happen; and it is a thing unworthy a philoſopher to look upon them as falſe and ridiculous.

Comets are not comprehended within the limits of a Zodiac, as the Planets are; but being confined to no bounds, are with various motions diſperſed all over the Heavens, namely, to this purpoſe, that in their aphelions, where their motions are exceeding ſlow, receding to greater diſtances one from another, they may ſuffer leſs diſturbance from

from their mutual gravitations. And hence it is, that the Comets which deſcend the loweſt, and therefore move the ſloweſt in their aphelions, ought alſo to aſcend the higheſt. Neither are the planes of the Comets' motions in the planes of the Ecliptic, or any of the planetary orbits; for had this been the caſe, it would have been impoſſible for the Earth, or any of the Planets, to have been out of the way of the Comets' tails. Nay, the poſſibility of an immediate rencounter or ſhock of the body of a Comet would then have been too frequent; and conſidering how great the velocity of a Comet is at ſuch a time, the colliſion of two ſuch bodies muſt neceſſarily be deſtructive of each other; nor perhaps could the inhabitants of Planets long ſurvive thoſe frequent immerſions in the tails of Comets, as they would be liable to in ſuch a ſituation, not to mention any thing of the irregularities and confuſion that muſt happen in the motion of Planets and Comets, if their orbits were all diſpoſed in the ſame plane.

The reaſon why Comets are ſo very numerous is, that a very few could not anſwer thoſe very great purpoſes before mentioned; for ſetting aſide the conſtant ſupply of planetary moiſture, an eſtimate of which cannot properly be formed, it is well known by experience, that the fire of the Sun is renewed and recruited very frequently; for the maculæ or ſpots in the Sun are only the parts burnt out, or a dead calx without fire; and theſe ſpots, after many years appearance and increaſe, will oftentimes diſappear on a ſudden, and will not be ſeen again for ſome years; which, I think, plainly ſhews that ſomething has happened to the Sun, by which thoſe dark or extinct parts are rekindled and burn again afreſh; and why may not this ariſe from Comets falling into the Sun? though we are well aſſured from obſervations, that Nature has provided ſome other means to anſwer this purpoſe, beſides the bodies of Comets.

Thus have I delivered as much concerning the natural hiſtory and philoſophy of Comets,

Comets, as I think can be of any uſe to my readers; for beſides what Hevelius, Flamſted, Newton, and Halley have ſaid on the ſubject, I can find nothing worth relating from others.

PART

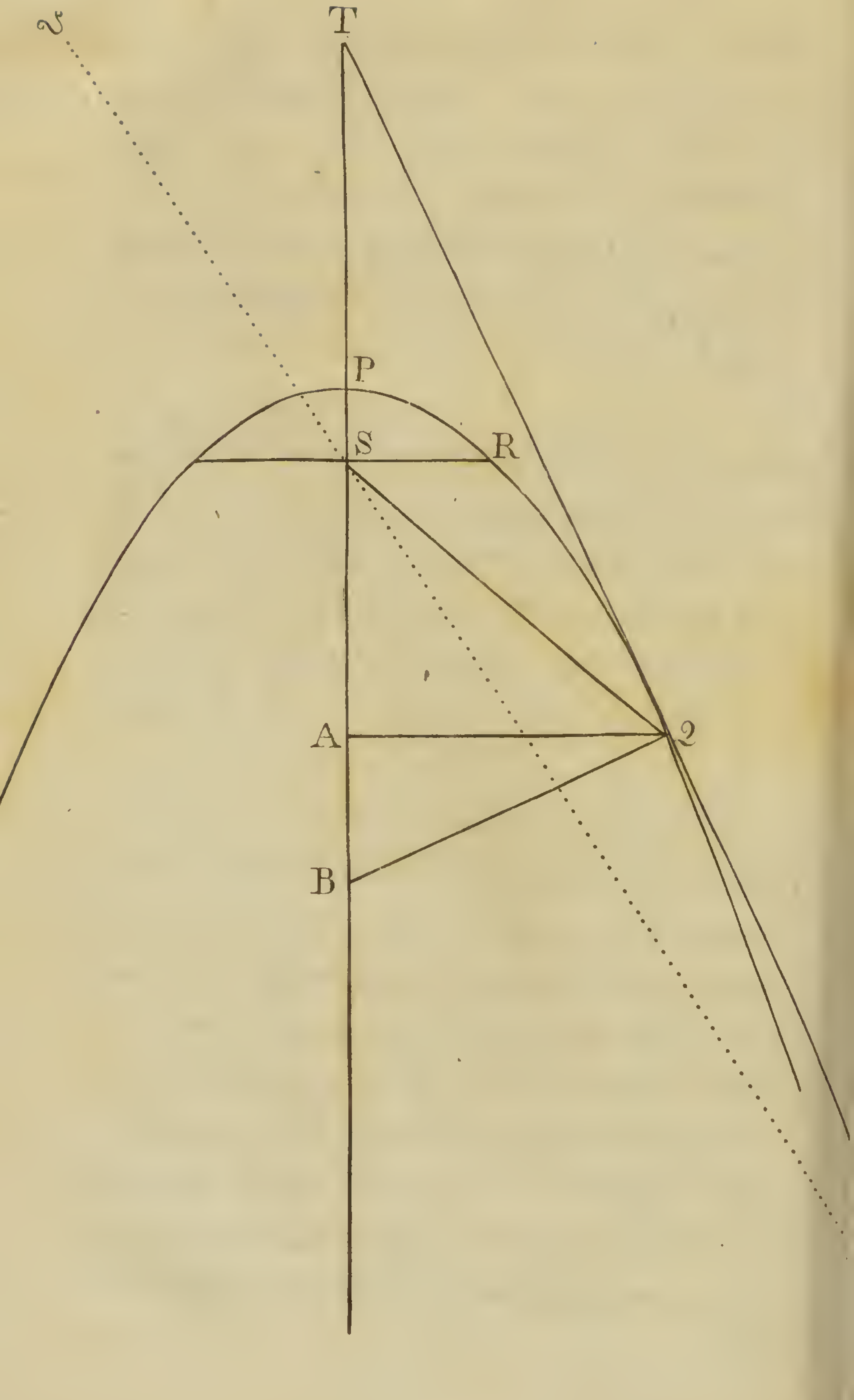
PART II.

The whole Process of COMETARY CALCULATION, *and Tables of the Elements of the Theory of a* COMET'S MOTION, *with their Construction and Use, exemplified in the Comet of* 1661, *which will again visit us in the latter End of the Year* 1789, *as we have great Reason to expect.*

I JUDGE it will be an agreeable amusement for my readers, to be instructed in a plain and practical method, requiring no more than a moderate skill in plane trigonometry, of calculating the place and distance of this Comet, both from the Sun and from the Earth, with its latitude and longitude in the Ecliptic for any given time during the Comet's appearance; and the same mode of calculation

calculation will ſerve for any other Comet whoſe period is known. For it is found by obſervation, that the cometary orbits are extremely eccentric; and that the portion which a Comet deſcribes during the time of its appearance, is but a very ſmall part of the whole. The center of ſuch an ellipſis being removed to ſo vaſt a diſtance, muſt occaſion the curvature at each end to be vaſtly near to that of a parabola, having the ſame focal diſtance; and conſequently the motion of a Comet may be calculated in a parabolic orbit, without any conſiderable error.

Now, as Comets may be ſuppoſed to move in ſuch orbits, having the Sun in their common focus; and it being well known that all parabolas, cut from ſimilar cones, are ſimilar; it therefore follows, that if any determinate part of the area of a given parabola be divided into any number of parts at pleaſure, there will be a like diviſion made in all parabolas under the ſame angles, and the diſtances will be proportionable.



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Thus in the following figure, let S be the Sun, PQR part of the orbit of the Comet expected, P the perihelion, R the place where the Comet is 90° diſtant from the Sun, Q the place of the Comet on the 1ſt of December Old Stile, or the 12th of December New Stile, 1789; draw QA perpendicular to the axis, and let *ab* be a tangent to the curve in the point Q, and perpendicular thereto draw BQ; then, by the nature of the parabola, we have AB = SR, the ſemilatus rectum. Put the given area PQS $= a$, and AQ $= x$, and we ſhall have $\frac{x^3}{12} + \frac{x}{4} = 12\,a$, or its equal $x^3 + 3x = 12a$, which ſolved will give the ordinate AQ, and from thence we get PA; but PA + PS = SQ, the Comet's diſtance from the Sun; then in the triangle SAQ, right angled at A, we have SQ and AQ known, and from thence we find the angle QSA, as alſo the angle PSQ, or the angle from the perihelion, is known.

The velocity of a Comet moving in a parabola is every where to the velocity of a

Planet deſcribing a circle about the Sun, at the ſame diſtance from the Sun as $\sqrt{2}$ to 1, that is, as the ſquare root of 2 to 1, by Cor. 77, prop. 16, lib. i. of the Principia.

If therefore a Comet in its perihelion were ſuppoſed to be as far diſtant from the Sun as the Earth is, then the diurnal area which the Comet would deſcribe, would be to the diurnal area of the Earth as $\sqrt{2}$ to 1; and conſequently, the time of the annual revolution of the Earth is, to the time in which ſuch a Comet would deſcribe a quadrant of its orbit from the perihelion, as 3.14159, &c. to $\sqrt{\frac{8}{9}}$, viz. as 3.14159, the circumference of a circle whoſe diameter is unity, is to 365.25 days, the time of one revolution of the Earth, ſo is .94281, the ſquare root of $\frac{8}{9}$, to 109 days 14 hours 46 minutes, the time in which a Comet would deſcribe a quadrant of its orbit from the perihelion. Now, ſeeing the Comet would deſcribe that quadrant in 109 days 14 hours 46 minutes, and ſo the parabolic area analagous to the area PRS, being divided into 100 parts, to each

each day there would be allotted 0.912280 of thoſe parts, whoſe log. 9.960128 is to be reſerved for conſtant uſe. But the time in which a Comet at a greater diſtance, or a leſs diſtance, would deſcribe a ſimilar quadrant, will be as the times of the revolutions in circles; that is, in the ſeſquiplicate ratio of the diſtances, and ſo the diurnal areas eſtimated in 100 parts of the quadrant, (which parts are to be put for meaſures of the mean motion, like degrees) are in each in the ſeſquialtera proportion of the diſtance from the Sun in the perihelion.

For the Comet expected in 1789, whoſe mean anomaly, or diurnal area, is firſt to be determined, thus: Put PS=1=the ſemidiameter of the Earth's orbit$=\frac{100}{109\text{d. }14\text{h. }46\text{m.}}$ =0.912280. The perihelion diſtance PS of this Comet, was obſerved to be ,44851, whence the diurnal area will be thus found, either by the logs, or numbers; but the logarithm being the moſt expeditious method, ſhall give an example by them. In order

 thereto,

thereto, I muſt premiſe this rule :—Take the ſquare root of the cube of the Comet's perihelion diſtance, and divide unity thereby; multiply the quotient by the conſtant factor 0.912280, or its log. 9.960128, the product will give the diurnal area required.

Comet's perihelion diſtance, .44851, log. —	6.348228
Multiply by — — —	3
Cube of the perihelion diſtance — —	2)19.044684
Divide by 2, gives the ſquare root — —	=9.522342
Conſtant log. — — —	9.960128
Log. of the diurnal area 3.037 — —	9.482470

Multiply this diurnal area 3.037, by the number of days and decimal parts of a day, if any, the product will be the area PRQS, or mean anomaly for the given time.—Thus:

	d.	h.	m.
Time of perihelion, January Old Stile, 1661	16	23	41
Given time, December 1, Old Stile, 1789 —	1	23	41
Before perihelion — — —	46	0	0

Then

Then 3.037, multiplied by 46, gives 139.702, the diurnal area or mean anomaly. Having therefore the area PRSQ$=139.702$, we find QA$=x$ from the equation $x^3+3x=12a$; for when the quadrantal area PSR is 100, if we put SR$=x=1$, we get $x^3+3x=4=12a$; and therefore, when the mean anomaly is but $\frac{1}{100}$ part of this, we ſhall have x^3+3x $=\frac{4}{100}=04$, a conſtant multiplier for reducing any anomaly to fit it for the equation. Thus .04 multiplied into 139.702, gives 5.588, but $x^3+3x=5.588$. Now it appears that x is ſomewhat more than 1, but conſiderably leſs than 2. Put $r=1$, then $r+z=x$, from whence we get r^3+3r^2z+3r $+3z=5.588.—$ $\therefore z=\frac{5.588.-r^3-3r}{3r^2+3}$. $=\frac{1.588}{6}=.264$, then $r+z=1.264=x$; this number being ſomewhat too great, I repeat the operation, by aſſuming $r=1.264$, and the value of x comes out 1.23507=AQ, extremely near,

Then,

Then, by the property of the parabola, we ſhall have $\frac{AQ^2}{4PS}=0.76269=AP$, but $AP+PS=QS=1.26269$, the diſtance of the Comet from the Sun for the given time: but to expreſs this diſtance in the ſame parts, the Sun's mean diſtance from the Earth contains 100000, we muſt conſider that the perihelion diſtance of the Comet PS is equal to .44851, whence $SK=.89702=2\,PS$, then ſay, as $1 : .89702 :: 1.26269 : 1.13266=SQ$, reduced; and as $1 : .89702 :: .26269 : .23564 =AS$; reduced alſo as $1 : .89702 :: 1.23507 : 1.10788=AQ$, reduced; which are the expreſſions required. For $AP=.76269+PS =.5=1.26269=SQ$. And $SQ=1.26269- SR=1=.26269=AS$. Then in the right-angled triangle QAS, we have all the ſides given, viz. AS, .23564 SQ, 1.13266 and AQ 1.10788. To find the angle QSA.

As SQ, 1.13266	—	—	—	0.054099
To Radius	—	—	—	10.000000
So is AQ, 1.10788		—	—	0.044493
To s. angle QSA 78°		—	—	9.990394

From

From 180° take the angle QSA 78°, there will remain 102°, the angle PSQ, the heliocentric diſtance of the Comet from the perihelion. And ſince the Comet's perihelion is in Cancer, 25 degrees 58 minutes 41 ſeconds; if therefore we now take

	S.	°	′	″
From — — —	3	25	58	41
The angle PSQ, 102°= — —	3	12	00	00
There will remain the Comet's place in its orb.	0	13	58	41
Comet's aſcending node — —	2	22	30	30
Comet from its aſcending node —	2	8	31	49

For the reduction of the Comet from its orbit to the Ecliptic, ſay,

As Radius — — —	10.000000
To ſc. 32° 35′ 50″ inclination Comet's orbit —	9.925693
So is t. 68° 31′ 49″ Comet from its node —	10.405275
To t. 64° 58′ 55″ reduction — —	10.330968

	S.	°	′	″
Comet's aſcending node — —	2	22	30	30
Reduction ſubtract — —	2	4	58	55
Comet's heliocentric longitude in the Ecliptic	0	17	31	35

For

For the Comet's heliocentric latitude:

As Radius	—	—	—	10.000000
To ſ. 68° 31′ 49″ Comet from its node			—	9.968768
So is ſ. 32° 35′ 50″ inclination		—	—	9.731371
To ſ. 30° 5′ 21″ heliocentric lat. Comet			—	9.700139

For the log. of the true diſtance of the Comet from the Sun:

Log. of the proper diſt. Comet from the Sun		—	0.402255
Log. of the Comet's perihelion diſtance		—	9.651772
Sum of the two logarithms	—	—	0.054027

As Radius	—	—	—	10.000000
To the ſum of the 2 logs.		—	—	0.054027
So is ſc. 30° 5′ 21″ heliocen. lat.		—	—	9.937191
To log. of the Comet's curtate diſtance			—	9.991218

Remark. If the curtate diſtance of the Comet from the Sun be greater than the diſtance of the Earth from the Sun, we muſt work in the calculation as is done in the calculation of the places of the ſuperior Planets; but if the curtate diſtance of the Comet

met from the Sun be leſs than the diſtance of the Earth from the Sun, the operations are to be performed as in the calculations of the inferior Planets.

To find the geocentric longitude of the Comet, or it's true place in the Heavens, as ſeen from the Earth: in order to which, we muſt compute the true place of the Sun, and the place of the Earth, together with the log. of the Earth's diſtance from the Sun, to the given time.

			S.	°	′	″		S.	°	′	″
December O. S.	1700	—	8	20	10	25	—	3	7	44	25
Comp. years	88	—			40	4	—		1	30	12
	1	—	11	29	45	40	—			1	1
Days —	1	—			59	8		3	9	15	38
Hours —	23	—			56	40					
Minutes —	1	—			1	41					
Sun's mean motion		—	8	22	33	38					
Apogee —		—	3	9	15	38					
Sun's mean anomaly		—	5	13	18	00					
Equa. Sun's center		—			34	00					
Sun's place —		—	8	21	59	38					
True place of the Earth		—	2	21	59	38					

Log. of the Earth from the Sun.					9.992935
Log. of the Comet's curtate distance					9.991218
	°	′	″		
Tangent of	44	53	12		9.998283
Add	45	—	—		
Sum	89	53	12		

As Radius					10.000000
	°	′	″		
To tc.	89	53	12		7.285435
So is t.	57	45	58	Half ang. commut.	10.200273
To t.	0	10	28	An arc	7.485708

	S.	°	′	″
Heliocentric longitude of the Comet	0	17	31	35
Sun's longitude	8	21	59	38
Anomaly of commutation	3	25	31	57
Its half	1	27	45	58
Fourth arc, add and subtract	0	0	10	28
Parallax of the Comet's orb	1	27	56	26
Elongation	1	27	35	30
Heliocentric longitude of the Comet	0	17	31	35
Parallax of its orb, subtract	1	27	56	26
Comet's geocentric longitude	10	19	35	9

For

For the geocentric latitude of the Comet:

		°	′	″		
As ſ. commutation	—	64	28	3	Co. ar.	0.044629
To ſ. elongation	—	57	35	30		9.926471
So is t. heliocentric latitude		30	5	21		9.762999
To t. geocentric latitude		28	27	48		9.734099

By this calculation it appears, that on the 13th of December 1789, New Stile, the Comet will be in the ſign Aquarius, 19 degrees 35 minutes 9 ſeconds, with 28 degrees 27 minutes 48 ſeconds N. latitude; and at eight o'clock that evening may be ſeen, if the air be clear, near the ſmall Star in the head of Aquarius, about 25 degrees above the weſtern horizon.

For the latitude and longitude of the Comet on the 11th of December, 23 h. 41 m. 1789, Old Stile, aſſume another point Q, and draw AQ perpendicular to the axis; then, by rule page 44, the Comet's diurnal area was 3.037, and the above time 36 days before perihelion: whence 3.037 multiplied

by 36, gives the mean anomaly or area PRSQ, equal to 109.332; this multiplied by the common multiplier .04, we ſhall have $4.37328 = x^3 + 3x$, which ſolved as in page 39, gives $x = 1.0604 =$ AQ, and $\frac{AQ^2}{4PS}$ $= 0.56222 =$ AP; then AP + PS = QS = 1.06222, the diſtance of the Comet from the Sun at the given time; which diſtance, expreſſed in the ſame parts as the Sun's mean diſtance from the Earth, contains 100000 (ſee p. 40) we get QS = 0.95283, AS = .05581, and AQ = 0.95120.

In the right-angled triangle QAS, are given the ſides SQ 0.25283, and AQ .95120. To find the angle QSA:

As SQ 0.95283	—	—	9.979015
To Radius	—	—	10.000000
So is AQ 0.95120	—	—	9.978272
To ſ. ang. QSA, 86° 39′	—	—	9.999257

From 180° take the angle QSA, 86° 39′, and there will remain the angle PSQ, 93° 21′,

the

the heliocentric diſtance of the Comet from the perihelion. Thus:

	S.	°	′	″
The Comet's perihelion is in - -	3	25	58	41
The angle PSQ 93° 21′ in ſigns - -	3	3	21	00
The Comet in its orb - - -	0	22	37	41
Comet's aſcending node - -	2	22	30	30
Comet from its node - - -	1	29	52	49

For the reduction:

	° ′ ″		
As Radius -		- - -	10.000000
To ſc. -	32 35 50	Inclination - -	9.925693
So t. -	59 52 49	Comet from its node -	10.236466
To t. -	55 27 23	Reduction - -	10.162159

	S.	°	′	″
Comet's aſcending node - -	2	22	30	30
Reduction ſubtract - - -	1	25	27	23
Comet's heliocentric ecliptic longitude -	0	27	3	7

Or the place in which the Comet would appear to an eye in the Sun.

For

For the Comet's heliocentric latitude:

As Radius				-	10.000000
To ſ.	59° 52′ 49″	Comet from its node		-	9.937004
So is ſ.	32 35 50	Inclination	-	-	9.731371
To ſ.	27 46 11	Heliocentric latitude		-	9.668375

For the log. Comet's true diſtance from the Sun:

Log. proper diſtance of the Comet from the Sun	0.330461
Log. Comet's perihelion diſtance - -	9.651772
Sum - - - - -	9.982233

As Radius - - - -	10.000000
To ſum of the two logs. - - -	9.982233
So is ſc. 27° 46′ 11″ heliocentric latitude -	9.946858
Log. Comet's curtate diſtance - -	9.929091

For the geocentric longitude of the Comet, or its true place in the Heavens, as ſeen from the Earth:

Compute

Compute again the true place of the Sun, and the place of the Earth, with the log. of the Earth's diſtance from the Sun; as in page 49.

		S.	°	′	″
Heliocentric longitude of the Comet	-	0	27	3	7
Sun's longitude - -	-	9	2	10	58
Anomaly of commutation -	-	3	24	52	9
Its half - - -	-	1	27	26	4

Log. of the Comet's curtate diſtance -	9.929091
Log. of the Earth from the Sun - -	9.992679
Tangent of 40° 49′ 11″ - -	9.936412
Add - 45 00 00	
Sum - 85 49 11	

As Radius - - - -	10.000000
To tc. 85° 49′ 11″ - - -	8.863853
So is t. 57 26 4 Half anom. commut. -	10.194716
To t. 6 31 17 An arc - -	9.058569

	S.	°	′	″
Half anomaly of commutation - -		57	26	4
Fourth arc, add and ſubtract - -		6	31	17
Parallax of the Comet's orb - -		63	57	21
Heliocentric longitude of the Comet -	0	27	3	7
Parallax of its orbit, ſubtract - -	2	3	57	21
Comet's geocentric longitude - -	10	23	5	46

For the geocentric latitude:

	°	′	″		
As ſ. commutation -	65	7	51	Co. ar.	0.042264
To ſ. elongation -	50	54	47	-	9.889967
So is t. heliocentric latitude	27	46	11	-	9.721452
To t. geocentric latitude	24	15	4	-	9.653683

Whence, on the 23d of December, New Stile, 1789, the Comet will be in Aquarius, 23° 5′ 46″, with 24° 7′ 4″ North latitude, its right aſcenſion then 328 degrees; and about eight o'clock that evening, if clear, will be ſeen in the jaw of Pegaſus, near the Star Enif.

Thus

Thus having ſhewn the method of computation from the properties of the parabola, it now remains that I ſhould ſhew the mode of calculation by the following Tables, which are conſtructed by the foregoing calculation, as in pages 41, 42, 43, 44, 45, and 46.

As, in the foregoing and following computations, I have made choice of the Comet of 1661, which is again expected in 1789, I think it will be expedient to ſhew the reaſons why we expect its return, that it may appear we have ſufficient grounds for our theory and computations. To this purpoſe I ſhall lay down the following criterions, or proofs of the ſame Comet returning, ſo that we may not be liable to miſtake one for another:

1ſt. The intervals or periods of time in which the Comet appears, muſt be among themſelves nearly equal, and determined from obſervations.

2d. The aſcending node of the ſame Comet muſt be obſerved at each appearance to have nearly the ſame place in the Ecliptic.

3d. That the inclination of the plane of ſuch a Comet's orbit be obſerved to be at each appearance nearly of the ſame quantity.

4th. The place of the perihelion muſt alſo be found to poſſeſs the ſame part of the Ecliptic nearly.

5th. The perihelion diſtance muſt alſo be very nearly the ſame at each return.

6th. The time of the year in which the perihelion happens, muſt be nearly the ſame at each return.

7th. The ſame Comet returning, muſt have always the ſame direction of mo-

tion:

tion: if it be direct at one time, it muſt be direct at another; if retrograde at its firſt appearance, it muſt be ſo at every appearance.

Table I. Astronomical Elements of the Theory

Year of Appear.	Ascending Node.	Inclination.	Perihelion from Sun.	Log. Perihe. dist.
	° ′ ″	° ′ ″	° ′ ″	
1337	♊ 24 21 0	32 11 0	♉ 7 59 0	9.609236
1472	♑ 11 46 20	5 20 0	♉ 5 33 30	9.734584
1531	♉ 19 25 0	17 56 0	♒ 1 39 0	9.753583
1532	♊ 20 27 0	32 36 0	♋ 21 7 0	9.706803
1556	♍ 25 42 0	32 6 0	♑ 8 50 0	9.666424
1577	♈ 25 52 0	74 32 45	♌ 9 22 0	9.263447
1580	♈ 18 57 20	64 40 0	♋ 19 5 50	9.775450
1585	♉ 7 42 30	6 4 0	♈ 8 51 0	0 038850
1590	♍ 15 30 40	29 40 40	♏ 6 54 30	9.760882
1593	♍ 14 14 15	87 58 0	♍ 26 19 0	8.949940
1596	♒ 12 12 30	55 12 0	♏ 18 16 0	9.710058
1607	♉ 20 21 0	17 2 0	♒ 2 16 0	9.768490
1618	♊ 16 1 0	37 34 0	♈ 2 14 0	9.579498
1652	♊ 28 10 0	79 28 0	♈ 28 18 40	9.928140
1661	♊ 22 30 30	32 35 50	♋ 25 58 41	9 651772
1664	♊ 21 14 0	21 18 30	♌ 10 41 25	10.011044
1665	♏ 18 2 0	76 5 0	♊ 11 54 30	9.027309
1672	♑ 27 30 30	83 22 10	♉ 16 59 30	9.843476
1677	♏ 26 49 10	79 3 15	♌ 17 37 5	9.448072
1680	♑ 2 2 0	60 56 0	♐ 22 39 30	7.787106
1682	♉ 21 16 30	17 56 0	♒ 2 52 45	9.765877
1683	♍ 23 23 0	83 11 0	♊ 25 29 30	9.748343
1684	♐ 28 15 0	65 48 40	♏ 28 52 0	9 982339
1686	♓ 20 34 40	31 21 40	♊ 17 0 30	9.511883
1698	♐ 27 44 15	11 46 0	♑ 00 51 15	9.839660
1699	♌ 21 45 35	69 20 0	♏ 2 31 6	9.871570
1702	♎ 9 25 15	4 30 0	♌ 18 41 3	9.810165
1706	♈ 13 11 40	55 14 10	♊ 12 29 10	9 629218
1707	♉ 22 46 35	88 36 0	♊ 19 54 56	9 934368
1718	♌ 8 43 0	30 20 0	♌ 1 30 0	10.011380
1723	♈ 14 16 0	49 59 0	♉ 12 52 20	9.999414
1729	♒ 10 32 37	76 58 4	♒ 22 40 0	10.629552
1737	♏ 16 22 0	18 20 45	♒ 25 55 0	9.347960
1739	♈ 27 25 14	55 42 44	♋ 12 38 40	9.828388
1742	♎ 5 38 29	66 59 14	♏ 7 35 13	9.884049
1743	♊ 18 21 15	2 19 33	♋ 2 41 45	9.921690
1744	♉ 15 46 11	47 5 18	♎ 17 10 0	9.347325
1747	♒ 27 18 50	79 6 20	♑ 7 2 0	10.342128
1748	♏ 22 52 15	85 27 0	♏ 5 0 50	9.924624

of all the PRINCIPAL COMETS, to the Year 1748.

Dist. Perih. from the Sun.	Time of Perihelion.	d.	h.	m.	Perihelion from the Node. °	′	″	Direction of Motion.
40666	June	2	6	25	46	22	0	Retrograde.
54273	February	28	22	23	123	47	10	Retrograde.
56700	August	24	21	18½	107	46	10	Retrograde.
50910	October	19	22	12	30	40	0	Direct.
66390	April	21	20	3	103	8	0	Direct.
18342	October	26	18	45	103	30	0	Retrograde.
59628	November	28	15	0	90	80	30	Direct.
109358	September	27	19	20	28	51	30	Direct.
57661	January	29	3	45	51	23	50	Retrograde.
89113	July	18	13	48	12	4	45	Direct.
51293	July	31	19	55	83	56	30	Retrograde,
58680	October	16	3	50	108	5	0	Retrograde.
37975	October	29	12	23	73	47	0	Direct.
84750	November	2	15	40	59	51	20	Direct.
44851	January	16	23	41	33	28	10	Direct.
102575½	November	24	11	52	49	27	25	Retrograde.
10649	April	14	5	15½	156	7	30	Retrograde.
69739	February	20	8	37	109	29	0	Direct.
28059	April	26	0	37½	99	12	5	Retrograde.
00612½	December	8	0	6	9	22	30	Direct.
58328	September	4	7	39	108	23	45	Retrograde.
56020	July	3	2	50	87	53	30	Retrograde.
96015	May	29	10	16	29	23	0	Direct.
32500	September	6	14	33	86	25	50	Direct.
69129	October	8	16	57	3	7	0	Retrograde.
74400	January	13	8	32	70	45	31	Retrograde.
64590	March	13	14	22	50	44	12	Retrograde.
42581	January	30	4	32	59	17	30	Direct.
85974	December	11	23	39	27	8	31	Direct.
102655	January	14	23	48	7	13	0	Retrograde.
99865	September	27	16	20	28	36	20	Retrograde.
426141	June	25	11	6	12	7	23	Direct.
22283	January	30	8	40	99	33	0	Direct.
67358	June	17	10	9	75	13	26	Retrograde.
76568	February	8	4	48	31	56	44	Retrograde.
83501	January	10	20	35	14	10	30	Direct.
22249½	March	1	8	13	151	23	49	Direct.
219851	March	3	7	20	50	16	50	Retrograde.
84067	April	28	19	35	17	51	25	Retrograde.

TABLE II. For calculating the MOTION and

Perih. dift. in Days.	True Anomaly.			Log. pro. dift. a' Sun.	Perih. dift. in Days.	True Anomaly.			Log. pro. dift. a' Sun.
	°	′	″			°	′	″	
1	1	31	40	0.000077	39	51	31	8	0.090910
2	3	3	15	0.000309	40	52	30	56	0.094596
3	4	34	43	0.000694	41	53	29	44	0.098300
4	6	6	0	0.001231	42	54	27	32	0.102019
5	7	37	1	0.001921	43	55	24	21	0.105752
6	9	7	43	0.002759	44	56	20	12	0.109490
7	10	38	2	0.003745	45	57	15	6	0.113240
8	12	7	54	0.004876	46	58	9	3	0.116995
9	13	37	17	0.006151	47	59	2	4	0.120756
10	15	6	7	0.007564	48	59	54	11	0.124518
11	16	34	20	0.009115	49	60	45	25	0.128278
12	18	1	54	0.010798	50	61	35	45	0.132035
13	19	28	47	0.012609	51	62	25	14	0.135792
14	20	54	54	0.014550	52	63	13	52	0.139544
15	22	20	14	0.016607	53	64	1	40	0.143291
16	23	44	44	0.018783	54	64	48	38	0.147029
17	25	8	22	0.021072	55	65	34	50	0.150762
18	26	31	8	0.023470	56	66	20	13	0.154482
19	27	52	55	0.025969	57	67	4	50	0.158192
20	29	13	47	0.028570	58	67	48	42	0.161890
21	30	33	40	0.031263	59	68	31	50	0.165578
22	31	52	32	0.034045	60	69	14	16	0.169254
23	33	10	23	0.036916	61	69	55	58	0.172914
24	34	27	12	0.039864	62	70	36	56	0.176527
25	35	42	59	0.042892	63	71	17	16	0.180188
26	36	57	41	0.045989	64	71	56	56	0.183803
27	38	11	20	0.049154	65	72	35	57	0.187404
28	39	23	54	0.052382	66	73	14	15	0.190978
29	40	35	23	0.055668	67	73	51	59	0.194540
30	41	45	47	0.059009	68	74	29	6	0.198085
31	42	55	6	0.062400	69	75	5	38	0.201614
32	44	3	20	0.065838	70	75	41	35	0.205122
33	45	10	29	0.069319	71	76	16	36	0.206612
34	46	16	35	0.072839	72	76	51	43	0.212080
35	47	21	36	0.076396	73	77	25	57	0.215529
36	48	25	33	0.079984	74	77	59	41	0.218963
37	49	28	27	0.083600	75	78	32	54	0.222378
38	50	30	19	0.087244	76	79	5	35	0.225769

Places of Comets in a Parabolic Orbit.

Perih. dist. in Days.	True Anomaly. ° ′ ″	Log. pro. dist. a' Sun.	Perih. dist. in Days.	True Anomaly. ° ′ ″	Log. pro. dist. a' Sun.
77	79 37 45	0.229142	130	99 33 11	0.379842
78	80 9 23	0.232488	132	100 4 43	0.384576
79	80 40 34	0.235809	134	100 35 45	0.389252
80	81 11 16	0.239127	136	101 5 48	0.393868
81	81 41 31	0.242416	138	101 35 22	0.398428
82	82 11 19	0.245684	140	102 4 19	0.402930
83	82 40 40	0.248933	142	102 32 41	0.407380
84	83 9 34	0.252159	144	103 00 31	0.411784
85	83 38 4	0.255366	146	103 27 47	0.416132
86	84 6 8	0.258552	148	103 54 31	0.420430
87	84 33 49	0.261720	150	104 20 43	0.424676
88	85 1 5	0.264865	152	104 46 22	0.428866
89	85 27 58	0.267989	154	105 11 33	0.433012
90	85 54 27	0.271092	156	105 36 16	0.437110
91	86 20 34	0.274176	158	106 00 32	0.441164
92	86 46 20	0.277239	160	106 24 23	0.445178
93	87 11 43	0.280284	162	106 47 47	0.449144
94	87 36 45	0.283306	164	107 10 44	0.453060
95	88 1 27	0.286308	166	107 33 17	0.456936
96	88 25 49	0.289293	168	107 55 27	0.460772
97	88 49 48	0.292252	170	108 17 14	0.464208
98	89 13 32	0.295201	172	108 38 37	0.468318
99	89 36 54	0.298122	174	108 59 39	0.472030
100	90 0 0	0.301030	176	109 20 20	0.475705
102	90 45 14	0.306782	178	109 40 40	0.479340
104	91 29 18	0.312469	180	110 00 40	0.482937
106	92 12 14	0.318060	182	110 20 20	0.486498
108	92 54 4	0.323587	184	110 39 41	0.490022
110	93 34 52	0.329042	186	110 58 44	0.493512
112	94 14 40	0.334424	188	111 17 28	0.496965
114	94 53 30	0.339736	190	111 35 55	0.500384
116	95 31 22	0.344979	192	111 54 5	0.503769
118	96 8 22	0.350153	194	112 11 58	0.507121
120	96 44 30	0.355262	196	112 29 34	0.510441
122	97 19 48	0.360306	198	112 46 55	0.513729
124	97 54 17	0.365284	200	113 4 0	0.516984
126	98 28 00	0.370200			
128	99 00 57	0.375052			

TABLE III. Of the RADICAL MEAN PLACES and MOTIONS of the SUN, for Years and Months, Old Stile, Greenwich Latitude 51° 28′ 30″ N. Longitude 00° 00′.

1700. JULIAN, or OLD STILE.									
MONTHS.		ME. PLACE SUN.				M. PL. SUN'S APO.			
		S.	°	′	″	S.	°	′	″
January	1.	9	20	58	3	3	7	43	29
February	1.	10	21	31	21	3	7	43	31
March	0.	11	19	7	14	3	7	43	39
April	0.	0	19	40	33	3	7	43	44
May	0.	1	19	14	43	3	7	43	49
June	0.	2	19	43	1	3	7	43	51
July	0.	3	19	22	11	3	7	43	59
Auguſt	0.	4	19	55	29	3	7	44	5
September	0.	5	20	28	47	3	7	44	10
October	0.	6	20	2	57	3	7	44	15
November	0.	7	20	36	15	3	7	44	20
December	0.	8	20	10	25	3	7	44	25
YEARS JULIAN.		MEAN MOT. SUN.				M. MO. SUN'S APO.			
100		0	0	45	32	0	1	42	30
200		0	1	31	4	0	3	25	0
300		0	2	16	36	0	5	7	30
400		0	3	2	8	0	6	50	0
500		0	3	47	40	0	8	32	30

TABLE

TABLE IV. MEAN MOTION of the SUN for 99 Julian Years.

Jul. Years	MEAN MOT. OF SUN.				MEAN MO. OF APOGEE			
	S.	°	′	″	S.	°	′	″
4	0	0	1	49	0	0	4	46
8		+	3	39		+	8	12
12			5	28			12	18
16			7	17			16	24
20			9	6			20	30
24			10	56			24	36
28			12	45			28	42
32			14	34			32	48
36			16	24			36	54
40			18	13			41	0
44			20	2			45	6
48			21	51			49	12
52			23	41			53	18
56			25	30			57	24
60			27	19		1	1	30
64			29	8		1	5	36
68			30	58		1	9	42
72			32	47		1	13	48
76			34	37		1	17	54
80			36	26		1	22	0
84			38	15		1	26	6
88			40	4		1	30	12
92			41	53		1	34	18
96			43	43		1	38	24
1	11	29	45	40			1	1
2	11	29	31	20			2	3
3	11	29	17	1			3	4

TABLE V. MEAN MOTION of the SUN for DAYS, HOURS, MINUTES, and SECONDS.

Days	Mean Motion of Sun.	Sun's Apo.	H. Min. Sec.	° ′ ″ / ′ ″ ‴ / ″ ‴ ⁗	H. Min. Sec.	° ′ ″ / ′ ″ ‴ / ″ ‴ ⁗
	S. ° ′ ″					
1	59 8	0	1	0 2 28	31	1 16 23
2	1 58 17	0	2	4 56	32	1 18 51
3	2 57 25	0	3	7 24	33	1 21 19
4	3 56 33	1	4	9 51	34	1 23 47
5	4 55 42	1	5	12 19	35	1 26 14
6	5 54 50	1	6	14 47	36	1 28 42
7	6 53 58	1	7	17 25	37	1 31 10
8	7 53 7	1	8	19 43	38	1 33 38
9	8 52 15	1	9	22 11	39	1 36 6
10	9 51 23	2	10	24 38	40	1 38 34
11	10 50 32	2	11	27 6	41	1 41 1
12	11 49 40	2	12	29 34	42	1 43 29
13	12 48 48	2	13	32 2	43	1 45 57
14	13 47 57	2	14	34 30	44	1 48 25
15	14 47 5	2	15	36 58	45	1 50 53
16	15 46 13	3	16	39 20	46	1 53 21
17	16 45 22	3	17	41 53	47	1 55 48
18	17 44 30	3	18	44 21	48	1 58 16
19	18 43 38	3	19	46 49	49	2 0 44
20	19 42 47	3	20	49 17	50	2 3 12
21	20 41 55	3	21	51 45	51	2 5 40
22	21 41 3	4	22	54 13	52	2 8 8
23	22 40 12	4	23	56 40	53	2 10 36
24	23 39 20	4	24	59 8	54	2 13 3
25	24 38 28	4	25	1 1 36	55	2 15 31
26	25 37 37	4	26	1 4 4	56	2 17 59
27	26 36 45	4	27	1 6 32	57	2 20 27
28	27 35 53	5	28	1 9 0	58	2 22 55
29	28 35 2	5	29	1 11 27	59	2 25 23
30	29 34 10	5	30	1 13 55	60	2 27 50
31	1 0 33 18	5		. .		

Table VI. Equation of the Sun's Center.

Argument Sun's Mean Anomaly.

☉'s M. A.	Signs 0. Subt.	Signs 1. Subt.	Signs 2. Subt.	Signs 3. Subt.	Signs 4. Subt.	Signs 5. Subt.	☉'s M. A.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	
0	0 0 0	0 56 52	1 39 15	1 55 49	1 41 22	0 59 0	30
1	1 59	0 58 36	1 40 16	1 55 50	1 40 22	57 12	29
2	3 58	1 0 18	1 41 15	1 55 49	1 39 20	55 23	28
3	5 57	1 1 59	1 42 13	1 55 46	1 38 16	53 34	27
4	7 56	1 3 39	1 43 8	1 55 42	1 37 10	51 44	26
5	9 54	1 5 18	1 44 2	1 55 35	1 36 3	49 53	25
6	11 52	1 6 57	1 44 54	1 55 26	1 34 53	48 1	24
7	13 50	1 8 33	1 45 44	1 55 15	1 33 41	46 8	23
8	15 48	1 10 9	1 46 33	1 55 1	1 32 28	44 14	22
9	17 45	1 11 43	1 47 19	1 54 45	1 31 13	42 19	21
10	19 42	1 13 16	1 48 3	1 54 29	1 29 57	40 23	20
11	21 39	1 14 48	1 48 45	1 54 9	1 28 38	38 27	19
12	23 36	1 16 19	1 49 25	1 53 47	1 27 19	36 31	18
13	25 32	1 17 47	1 50 4	1 53 23	1 25 57	34 33	17
14	27 28	1 19 16	1 50 41	1 52 57	1 24 34	32 34	16
15	29 23	1 20 42	1 51 15	1 52 9	1 23 9	30 35	15
16	31 17	1 22 7	1 51 48	1 51 58	1 21 42	28 36	14
17	33 11	1 23 30	1 52 19	1 51 26	1 20 14	26 36	13
18	35 5	1 24 52	1 52 47	1 50 52	1 18 45	24 35	12
19	36 58	1 26 13	1 53 14	1 50 16	1 17 13	22 34	11
20	38 51	1 27 33	1 53 38	1 49 38	1 15 41	20 32	10
21	40 43	1 28 50	1 54 1	1 48 56	1 14 7	18 29	9
22	42 34	1 30 6	1 54 21	1 48 13	1 12 31	16 26	8
23	44 24	1 31 20	1 54 39	1 47 29	1 10 55	14 23	7
24	46 13	1 32 33	1 54 55	1 46 43	1 9 16	12 20	6
25	48 2	1 33 34	1 55 9	1 45 55	1 7 37	10 17	5
26	49 50	1 34 54	1 55 21	1 45 4	1 5 56	8 14	4
27	51 37	1 36 2	1 55 31	1 44 11	1 4 14	6 11	3
28	53 23	1 37 8	1 55 39	1 43 16	1 2 31	4 8	2
29	55 8	1 38 13	1 55 45	1 42 20	1 0 46	2 4	1
30	56 52	1 39 15	1 55 49	1 41 22	0 59 0	0 0 0	0
☉'s M. A.	Add Signs 11.	Add Signs 10.	Add Signs 9.	Add Signs 8.	Add Signs 7.	Add Signs 6.	☉'s M. A.

Table

TABLE VII. LOGS. of SUN'S DIST. from the EARTH ECCENTRICITY 1685.

ARGUMENT SUN'S MEAN ANOMALY.							
☉'s M. A.	Signs 0. ☉ a' ⊕.	Signs 1. ☉ a' ⊕.	Signs 2. ☉ a' ⊕.	Signs 3. ☉ a' ⊕.	Signs 4. ☉ a' ⊕.	Signs 5. ☉ a' ⊕.	☉'s M. A.
0	5.007257	5.006320	5.003736	5.000122	4.996424	4.993656	30
1	5.007257	5.006260	5.003628	4.999991	4.996310	4.993590	29
2	5.007252	5.006196	5.003520	4.999861	4.996201	4.993524	28
3	5.007248	5.006132	5.003409	4.999735	4.996091	4.993463	27
4	5.007240	5.006063	5.003297	4.999609	4.995981	4.993401	26
5	5.007231	5.005990	5.003185	4.999483	4.995872	4.993343	25
6	5.007218	5.005918	5.003068	4.999357	4.995762	4.993286	24
7	5.007205	5.005845	5.002952	4.999230	4.995653	4.993233	23
8	5.007188	5.005772	5.002835	4.999104	4.995547	4.993180	22
9	5.007171	5.005695	5.002719	4.998978	4.995442	4.993132	21
10	5.007150	5.005618	5.002602	4.998852	4.995341	4.993088	20
11	5.007128	5.005540	5.002486	4.998725	4.995244	4.993043	19
12	5.007103	5.005459	5.002369	4.998599	4.995148	4.992999	18
13	5.007077	5.005378	5.002248	4.998473	4.995051	4.992960	17
14	5.007047	5.005292	5.002127	4.998346	4.994955	4.992920	16
15	5.007017	5.005206	5.002006	4.998220	4.994862	4.992885	15
16	5.006987	5.005120	5.001885	4.998093	4.994770	4.992849	14
17	5.006953	5.005030	5.001764	4.997971	4.994678	4.992818	13
18	5.006919	5.004940	5.001643	4.997848	4.994590	4.992787	12
19	5.006881	5.004845	5.001517	4.997727	4.994502	4.992761	11
20	5.006838	5.004751	5.001392	4.997605	4.994414	4.992739	10
21	5.006795	5.004652	5.001266	4.997482	4.994330	4.992717	9
22	5.006748	5.004553	5.001141	4.997360	4.994247	4.992699	8
23	5.006701	5.004454	5.001015	4.997238	4.994167	4.992681	7
24	5.006650	5.004356	5.000889	4.997120	4.994088	4.992664	6
25	5.006598	5.004257	5 000764	4.997002	4.994013	4.992651	5
26	5.006547	5.004158	5.000638	4.996883	4.993938	4.992637	4
27	5.006491	5.004055	5.000512	4.996770	4.993864	4.992628	3
28	5.006436	5.003951	5.000382	4.996652	4.993793	4.992624	2
29	5.006380	5.003844	5.000252	4.996538	4.993722	4.992620	1
30	5.006320	5.003736	5.000122	4.996424	4.993656	4.992620	0
☉'s M. A.	☉ a' ⊕. Signs 11.	☉ a' ⊕ Signs 10	☉ a' ⊕ Signs 9.	☉ a' ⊕ Signs 8.	☉ a' ⊕ Signs 7.	☉ a' ⊕ Signs 6.	☉'s M. A.

THE

THE foregoing Tables will ſerve to repreſent the motions of all our Comets; of which hitherto there has been none obſerved, but thoſe that come within the laws of the parabola.

Theſe neceſſary things being premiſed, it now remains that I ſhew rules and examples for computing the apparent place of any one of the beforementioned Comets for any given time, and in particular for the Comet of 1661, which will appear again in 1789. Therefore,

1. Let the Sun's place be had, and the logarithm of its diſtance from the Earth for the given time.

2. Let the difference between the time of the perihelion and the time given be gotten, in days and decimal parts of days. To the logarithm of this number let there be added the conſtant logarithm 9.960128, and the arithmetical complement of $\frac{3}{2}$ of the logarithm of

of the perihelion diſtance of the Comet from the Sun: the ſum will be the logarithm of the mean motion, to be ſought in the firſt column of the general table, viz. table ii. p. 62.

3. With the mean motion let there be taken the correſpondent angle from the perihelion in the ſame table, and the logarithm for the diſtance from the Sun: then in Comets that are direct, add, and in retrograde ones ſubtract (if the time be after the perihelion) the angle thus found to or from the perihelion; or in direct Comets ſubtract, and in retrograde ones add (if the time be before the perihelion) the aforeſaid angle to or from the place of the perihelion, ſo ſhall we have the place of the Comet in its orb: and to the logarithm for the diſtance found, add the logarithm of the diſtance at the perihelion; the ſum will be the logarithm of the true diſtance of the Comet from the Sun.

4. The

4. The place of the node, together with the place of a Comet in its orb, being had, let the diſtance of the Comet from the node be taken; then the inclination of the orbit being known from table i. p. 60, we by the common rules of trigonometry may compute the Comet's place reduced to the ecliptic, the inclination, or heliocentric latitude; and the logarithm of its curtate diſtance.

From the foregoing elements being determined, we may, by the ſame rules that we compute a Planet's place from the Sun's place and diſtance given, find the geocentric place both in latitude and longitude of a Comet, as I ſhall ſhew at large further on; in the mean time ſhall, in order to remove every obſtacle or apparent difficulty, premiſe a few neceſſary remarks.

The logarithm of days is added to the given logarithm of one day, that the motion of one day may be underſtood to be multiplied by the number of days; for it is well

known that the addition of logarithms doth infer the multiplication of numbers corresponding to thoſe logarithms; and theſe things may ſuffice, if ſo be the Comet be ſuppoſed to paſs in its perihelion at a diſtance equal to a radius of the orbis magnus. But if, which commonly is the caſe, the Comet doth not paſs at that diſtance, but at a greater, as it is ſometimes; or at a leſs, as oftener happens, that area proportional to the time is to be increaſed, or diminiſhed, and this in the ſub-ſeſquialteral proportion of that leaſt diſtance from the Sun; ſo that at length that area may rightly repreſent the mean anomaly: from whence the logarithm of that ſeſquiplicate diſtance is to be added to the former ſum of the logarithms, and the radius to be ſubtracted according to the exigence of the golden rule to be practiſed in logarithms; or, which is the ſame, the arithmetical complement only of that ſeſquialteral logarithm is to be added. Now it ought not to ſeem ſtrange, that in leſſer diſtances we, by adding the logarithm, obtain the true proportion increaſed, and the

ſame

ſame greater diſtances diminiſhed: for multiplication by a fraction, vulgar or decimal, doth no leſs diminiſh the ſum than multiplication by whole numbers doth increaſe it, and the thing is the ſame in logarithmetical addition. Alſo it muſt be obſerved, that the logarithms ſet down in the third column of table ii. p. 62, are not the logarithms of the numbers of the diſtances from the Sun, to be added over and above the radius to the mean diſtances; but of numbers, by the multiplication of which that true diſtance were to be obtained: from whence the logarithms of the ſame being ſuperadded to one another, will eaſily give us the logarithm of that whole diſtance from the Sun.

Theſe things being well underſtood, we ſhall be able to undertake and perform the whole proceſs of calculation, not only of this Comet, which is expected to make its appearance in 1789, but alſo of any other Comet, inſerted in the firſt or general table, p. 60.

A CALCULATION of the LONGITUDE and LATITUDE of the COMET which is expected to make its appearance in the latter end of the year 1789, for the 21ſt day of December, 23 h. 41 m. P. M. Old Stile, or the 2d of January, about noon, 1790, New Stile.

			d.	h.	m.
Comet's perihelion, 1661, January O. S.	—		16	23	41
Given time, December 1789, N. S.	—		21	23	41
Preceding the perihelion	—		26	00	00
Sun's true longitude then	—	9	12	22	37

Logarithm of the Earth from the Sun	—	9.992629
Log. of the Comet's perihelion from the Sun	—	9.651772
Mult. by 3, gives the cube of the perih. diſt.	—	8.955316
Divide by 2, gives the log. ſeſquialtrate	—	9.477658
Its arithmetical complement is	—	0.522342
Conſtant log. (ſee p. 43)	—	9.960128
Log. of the given time, 26 days	—	1.414973
Log. of the Comet's mean motion, 78.97	—	1.897443

		°	′	″
Comet's mean anomaly anſwering thereto	—	80	39	38
Comet's proper diſtance from the Sun, log.	—	0.235709		

Comet's

	S.	°	′	″
Comet's perihelion place — —	3	25	58	41
Anomaly of the Comet above is —	2	20	39	28
Comet in its orbit — — —	1	5	19	3

Comet's afcending node — —	2	22	30	30
Comet's orbit place, fubtract — —	1	5	19	3
Comet's diftance from its node — —	1	17	11	27

Comet's afcending node - -	2	22	30	30
Reduction fubtract - - -	1	12	17	43
Comet's heliocentric ecliptic place - -	1	10	12	47

For the reduction:

	°	′	″		
As Radius - - - -					10.000000
To fc. -	32	35	50	Comet's inclination, tab. 1.	9.925693
So is t. -	47	11	27	Comet from its node -	10.033244
To t. -	42	17	43	Reduction - -	9.958937

For the Comet's heliocentric latitude:

As Radius - - - -					10.000000
To f.	47°	11′	27″	Comet from its node -	9.865471
So is f.	32	35	50	Comet's inclination -	9.731371
To f.	23	16	48	Comet's heliocentric latitude	9.596842

For the logarithm of the Comet's true diſtance from the Sun;

Log. of the Comet's proper diſtance from the Sun	0.235709
Log. Comet's perihelion diſtance - -	9.651772
Sum of the two logarithms - - -	9.887481

As Radius - - - -	10.000000
To the ſum of the two logs. - -	9.887481
So is ſc. 23° 16′ 48″ Comet's heliocentric latitude	9.963119
To log. of the Comet's curtate diſtance -	9.850600

For the geocentric longitude of the Comet:

	S.	°	′	″
Heliocentric longitude of the Comet -	1	10	12	47
Sun's true longitude - - -	9	12	22	37
Anomaly of commutation - -	3	27	50	10
Its half is - - - -	1	28	55	5

Log. of the Comet's curtate diſtance -		9.850600
Log. of the Earth from the Sun - -		9.992629
Tangent of - -	35° 47′ 38″	9.857971
Add -	45 00 00	
Sum -	80 47 38	

As

As Radius				- - - -	10.000000
To tc.	80°	47′	38″	The ſum - -	9.209714
So is t.	58	55	5	Half anom. commut. -	10.219820
To t.	15	2	5	A fourth arc - -	9.429534

	S.	°	′	″
Half anomaly of commutation - -		58	55	5
Fourth arc, add and ſubtract - -		15	2	35
Parallax of the Comet's orb, ſubtract -		73	57	40
Elongation, add - - -		43	52	30
Comet's heliocentric longitude - -	1	10	12	47
Parallax of the Comet's orb, ſubtract -	2	13	57	40
Comet's geocentric longitude - -	10	26	15	7

For the Comet's geocentric latitude:

		°	′	″		
As ſ.	—	62	9	50	Commutation co. ar.	0.053407
To ſ.	—	43	52	30	Elongation —	9.840787
So is t.	—	23	16	48	Heliocentric latitude	9.633725
To t.	—	18	38	7	Geocentric latitude	9.527919

Whence, on the 2d of January, 1790, the Comet will be near the eye of Pegaſus, about 13° above the weſtern horizon, right aſcenſion 328°.

I ſhall

I ſhall give another Example of Computation for the LATITUDE and LONGITUDE of this COMET, for the 1ſt of January, O. S. 1789-90, or January 13, near Noon, 1790, N. S. in which I ſhall note down each ſtep.

	d.	h.	m.
Comet's perihelion, 1661, Jan. O. S. p. 60, tab. 1.	16	23	41
Given time, January — — —	1	23	41
Preceding the perihelion — —	15	00	00

For the Sun's true longitude:

	Sun's Mean Mo. S.	°	′	″		Mean Mo. Apo. S.	°	′	″
January 1700, O. S.	9	20	58	3	T. iii. p. 64.	3	7	43	29
Comp. years { 88 -			40	4	T. iv. p. 65.		1	30	12
Comp. years { 1 -	11	29	45	40	Ditto —			1	1
Day - 1 -			59	8	T. v. p. 65.				0
Hours - 23 -			54	13	Ditto —				0
Minutes - 41 -			1	41	Ditto —				0
Sun's mean motion	9	23	18	49	—	3	9	14	42
Apo. ſubt. -	3	9	14	42					
Sun's mean anom.	6	14	4	7					
Equa. center add —			28	44	T. vi. p. 66.				
Sun's longitude —	9	23	47	33					

Log. of the Earth from the Sun, 9.992851, tab. vii. p. 67.

Log.

Log. of the Comet's perihelion, tab. i. p. 60 —	9.651772
Multiply by — — —	3
Log. cube of the perihelion — —	8.955316
Divide by 2 log. ſeſquialtrate — —	9.477658
Complement arithmetical — —	0.522342
Conſtant log. p. 43 — — —	9.960128
Log. of the time, viz. 15 days — —	1.176091
Log. of the Comet's mean motion, viz. 45.56 —	1.658561

	°	′	″
Comet's mean anom. anſwering thereto, tab. ii. p. 62.	57	48	18

Log. Comet's proper diſtance from the Sun, ſame p.	0.115341

	S.	°	′	″
Comet's perihelion place, tab. i. p. 60 —	3	25	58	41
Comet's mean anomaly above in ſigns, is —	1	27	48	18
Comet in its orbit — —	1	28	10	23
Comet's aſcending node, tab. i. p. 60 —	2	22	30	30
Comet from its node — —	0	24	20	7

For the reduction:

	°	′	″		
As Radius —				— —	10.000000
To ſc. —	32	35	50	Comet's inclination, tab. 1.	9.925693
So is t.	24	20	7	Comet from its node —	9.655386
To t.	20	51	49	Reduction — —	9.581079

Comet's

		S.	°	′	″
Comet's aſcending node, tab. i. p. 60	—	2	21	30	30
Reduction ſubtract —	—		20	51	49
Heliocentric ecliptic longitude of the Comet	—	2	1	38	41

For the Comet's heliocentric latitude:

	°	′	″		
As Radius				— — —	10.000000
To ſ.	24	20	7	Comet from its node —	9.614977
So is ſ.	32	35	50	Comet's inclination —	9.731371
To ſ.	12	49	25	Comet's heliocentric latitude	9.346348

For the log. of the Comet's true diſtance from the Sun:

Log. of the Comet's proper diſtance from the Sun	0.115341
Log. of the Comet's perihelion diſtance —	9.651772
Sum of the 2 logs. — —	9.767113

As Radius — — —	10.000000
To the ſum of the 2 logs. — —	9.767113
So is ſc. 12° 49′ 25″ Comet's heliocentric latitude	9.989030
To log. of the Comet's curtate diſtance —	9.756143

For

For the geocentric longitude of the Comet:

		S.	°	′	″
Heliocentric longitude of the Comet	— —	2	1	38	41
Sun's true longitude	— —	9	23	47	33
Anomaly of commutation	— —	4	7	51	8
Its half is	— — —	2	3	55	34

Log. Comet's curtate distance	— —	9.756143
Log. of the Earth from the Sun	— —	9.992851
Tangent of 30° 6′ 22″	— —	9.763292
Add — 45 0 0		
Sum — 75 6 22		

As Radius				— — —	10.000000
To tc.	75°	6′	22″	The sum — —	9.424825
So is t.	63	55	34	Half anom. commut. —	10.310398
To t.	28	31	32	A fourth arc — —	9.735223

		S.	°	′	″
Half anomaly of commutation	—		63	55	34
Fourth arc, add and subtract	— —		28	31	32
Parallax of the Comet's orb, subtract	—		92	27	6
Elongation, add	— —		35	24	2
Comet's heliocentric longitude	— —	2	1	38	41
Parallax of the Comet's orb, subtract	—	3	2	27	6
Comet's geocentric longitude	— —	10	29	11	35

For the Comet's geocentric latitude:

	°	′	″		
As ſ.	52	8	52	Commutation co. ar. —	0.102594
To ſ.	35	24	2	Elongation — —	9.762895
So is t.	12	49	25	Comet's heliocentric latitude	9.357225
To t.	9	28	9	Comet's geocentric latitude	9.222714

To find the Comet's diſtance from the Earth in miles, on the 2d of December, Old Stile, at noon; the ſolar parallax 10 ſeconds.

As Radius — — —	10.00000
To ſ. 68° 32′ Comet from its node — —	9.96878
So is SQ 0.8265 — — —	9.91724
To QN 0.7692 — — —	9.88602

As Radius — — —	10.00000
To ſ. 32° 36′ Comet's inclination — —	9.73141
So is QN 0.7692 — — —	9.88602
To QP 0.4144 — — —	9.61743

As ſ. 28° 28′ geocentric latitude	—		—	9.67821
To QD 0.4144	—	—	—	9.61745
So is Radius	—	—	—	10.00000
To TQ 0.8694, the Comet from the Earth			—	9.93924

As 10000 to .8694, ſo is 81000000 mean diſt. of the Earth from the Sun.

$$\begin{array}{r} 81000000 \\ \hline 8694000000 \\ 69552 \\ \hline \end{array}$$

10000)704214000000(70421400 Miles the Comet from the Earth, on the 13th of December, at noon, 1789, New Stile.

How to delineate the VISIBLE PATH of a COMET among the fixed STARS, on the Surface of the CELESTIAL GLOBE.

THE method of drawing on a Globe the tract of a Comet, or its apparent path amongſt the Stars in the Heavens, is both eaſy and diverting, as we may by ſo doing be able to foreſee and ſhew what courſe the Comet will take during the time of its appearance, and alſo in what part of the Heavens it may be expected at any time aſſigned.

In order to the doing this, it will be neceſſary to make three obſervations on the place of the Comet at its firſt appearance, as correctly as we can at the diſtance of 24 or 48 hours from each other, as the ſtate of the air, &c. will permit.

Aſtronomers make uſe of ſeveral methods for inveſtigating the apparent place of a Comet; one of which is the method I am now going

going to explain. Thus ſtretch a thread over the Comet, and two known fixed Stars, in a right line with the Comet; then moving the thread into another poſition ſo as may bring the Comet into a right line with two other known fixed Stars, which is eaſily done among ſuch a vaſt number of Stars. Having thus got the poſition of the Comet in reſpect of theſe Stars in the Heavens, by finding the ſame Stars on the ſurface of the Globe, and laying the quadrant of altitude over each two reſpectively, and drawing lines between them with a pencil, thoſe lines will interſect each other in the place of the Comet in each obſervation; and thus the places of the Comet may be aſſigned on the ſurface of the Globe for any number of obſervations, and a circle paſſing through two or more places, thus marked on the Globe, will be the future way of the Comet.

It remains now that I explain the method of drawing the great circle above-mentioned, which is thus done: having got two, three, or more places of the Comet marked on the Globe,

Globe, let one of the poles of the Globe be raiſed or depreſſed, and the Globe turned about till the places of the Comet marked thereon coincide with the horizon, or touch it all at the ſame time; then, with a pencil, draw a great circle along the ſurface of the Globe by the horizon, and that will be the path of the Comet required, or its viſible way in the Heavens.

In the points where this circle interſects the Ecliptic will be the nodes of the orbit of the Comet; and the angle contained between this circle and the ecliptic, will be the inclination of the Comet's orbit to the plane of the Ecliptic; the quantity of which is readily meaſured at the 90th degree from the node, on the quadrant of altitude fixed over the pole of the Ecliptic, and laid on the ſaid 90th degree.

After this manner the place of the Comet for every night it can be ſeen, may be repreſented or protracted on the ſurface of the Globe; and thereby its longitude, latitude,

velocity

velocity of motion, and all things relative to it, may be eaſily defined.

Having all along conſidered the orbits of Comets as parabolic; upon which ſuppoſition it muſt follow, that Comets being impelled towards the Sun by a centripetal force, would deſcend as from ſpaces infinitely diſtant, and, by their ſo falling, acquire ſuch a velocity as that they may again fly off into the remoteſt parts of the univerſe, moving upwards with a perpetual tendency, ſo as never to return again to the Sun. But ſince they appear frequently enough, and ſince none of them can be found to move with an hyperbolic motion, or a motion ſwifter than what a Comet might acquire by its gravity to the Sun, it is highly probable they rather move in very eccentric elliptic orbits, and make their returns after very long periods of time. One principal uſe, therefore, of the

table, in page 60, of the Elements of the Cometary Motions, is, that whenever a new Comet ſhall appear, we may be able to know, by comparing together the Elements, whether it be any of thoſe which have appeared before; and conſequently, to determine its period, and the axis of its orbit; and alſo to foretell its return.

The Comet which Apian obſerved in the year 1531, was the ſame with that which Kepler and Longomontanus more accurately deſcribed in the year 1607, and which Dr. Halley obſerved in 1682; and, according to the prediction of the Doctor, the ſame Comet again viſited the earth in 1758; and was obſerved by Mr. Benjamin Martin, Dr. Patrick Browne, and many others; which leaves no room to doubt but the reſt may return alſo: for it is highly probable, that the Comet obſerved by Apian in the year 1532, was the ſame with that obſerved by Hevelius in the year 1661, which will again viſit us in the year 1789. As a further proof, and as far as probability from the equality of

of periods, and ſimilar appearance of Comets may be urged as an argument, the wonderful Comet of 1680, was the ſame which was ſeen in the reign of Henry the Firſt, anno 1106. As alſo in the conſulate of Lampadius and Oreſtes, about the year of Chriſt 531, of which Malela relates, that it was a great and fearful Star; now it is plain, that the interval between this and that of 1106, is nearly equal to that between 1106 and 1680, viz. about 575 years. And if we reckon backward ſuch another period, we ſhall come to the 44th year before Chriſt, in which Julius Cæſar was murdered, and in which there appeared a very remarkable Comet, mentioncd by almoſt all the hiſtorians of thoſe times, and by Pliny, in his Natural Hiſtory, Book xi. chap. 24. who recites the words of Auguſtus Cæſar on this occaſion, which leads us to the very time of its appearance, and its ſituation in the Heavens. Thus, it is probable, that this Comet has four times viſited us, at intervals of about 575 years.

I ſhall now conclude with wiſhing that the lovers of Aſtronomy will never let a Comet paſs without making neceſſary obſervations thereon, whenever it can be done with correctneſs.

F I N I S.